Burlington Woolen Company, Dam
(American Woolen Company, Dam)
Winooski River, immediately west of
bridge carrying Routes U.S. 2 and 7
between Winooski and Burlington
Chittendon County
Vermont

HAER No. VT-23-A

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VT
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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
MID-ATLANTIC REGION, NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR
PHILADELPHIA, PENNSYLVANIA 19106

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HISTORIC AMERICAN ENGINEERING RECORD

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Location:	Winooski River, immediately west of bridge carrying Routes U.S. 2 and 7 between Winooski and Burlington Chittendon County, Vermont USGS Burlington Quadrangle Universal Transverse Mercator Coordinates: 18.644110.4927560
Date of Construction:	1876
Present Owner:	Burlington Electrical Department 585 Pine Street Burlington, Vermont 05405
Lessee (99 years):	Winooski One Partnership 26 State Street Montpelier, Vermont 05602
Present Use:	Not in use; historically provided power for textile mill.
Significance:	Despite substantial erosion, the dam is significant as an example of timber-crib construction, a common 19th-century technology, and as one of the earliest-known dams to have used concrete as a structural material, in this case, the crib fill. It is also important as an integral component of the Winooski Falls Mills District, listed on the National Register of Historic Places.
Project Information:	The dam will be incorporated as the upstream face of a new concrete dam to be constructed at the site. This documentation was undertaken at the request of the State Historic Preservation Officer.

Bruce Clouette
Historic Resource Consultants
55 Van Dyke Avenue
Hartford, Connecticut 06106

DESCRIPTIVE OVERVIEW

The dam that is the subject of this documentation is part of a complex of mill buildings and waterpower features located on both banks of the Winooski River in Winooski and Burlington, Vermont. Known as Winooski Falls, the area was intensely developed for textile manufacturing in the 19th and early 20th centuries. Today there are two large brick mills near the remnants of the upper dam and another large mill at the lower falls; the latter was originally powered by this dam. All are vacant or converted to nonindustrial use. The area has been listed on the National Register of Historic Places as the Winooski Falls Mill District, and the 1912 Champlain Mill has been recorded by the Historic American Engineering Record (HAER No. VT-11).

The dam is a timber-crib structure built in 1876. It consists of 12" x 12" square criss-crossed timbers of hemlock (<u>Tsuga canadensis</u>).[1] Those laid across the river are spaced 4' on center, and those laid longitudinally in the direction of flow are spaced 5' on center. The transverse timbers have shallow mortises cut in them, and each intersection is secured with two or three 2" wooden pegs. The longitudinal timbers have an upstream slope of about 20 degrees.

The downstream face of the dam is vertical and is constructed of similar squared timbers of varying width, secured with 1" iron pins. The ends of the cribwork's longitudinal timbers are exposed where they tie in with the face timbers. Approximately 9 1/2' back from the downstream face are remnants of a wall of 2 1/2" planking. The cribwork between the face timbers and the upstream planking is filled with concrete consisting of large (3-8") pieces of broken limestone, sand, lime, and cement. The cribwork upstream of the planking appears to have been filled with loose stone and gravel. There are two waterways in the base of the structure. That near the west end is about 4' x 5' in area, while the east waterway has been eroded to a much larger opening by torrents of water passing through. There are no visible remnants of mechanisms to control these as gates. Indeed, they most likely represent waterways created during construction to allow the river to pass; the openings were closed off when the dam was completed and were not intended to be operated thereafter.

The dam is built on a natural limestone ledge, with a large outcropping forming an island in the middle of the river. Consequently, the depth of construction varies both transversely and longitudinally so as to take advantage of natural rock foundations. The transverse timbers are secured to the ledge with 1 1/2" iron pins and 6" washers. The largest portion of face timbering extends about 28' above the river bed, and the dam is about 125' in length. The maximum width of the structure, from the face timbers to the furthest visible remnant of the longitudinal timbers, is about 22'. Historically, the dam provided 35' of fall for the adjacent mill site.

Substantial erosion has occurred on all parts of the dam. Many face timbers are missing, revealing the concrete fill on the interior. The top of the dam, now rounded in shape, has been reduced by flood damage, losing several courses of cribwork in the process. The topmost tier of cribwork, extending upstream into the water, consists of only scattered remnants, and only about 15' of the upstream wall's planking remains intact. Typically, such a timber-crib dam would have had cap logs along its crest and planking across the entire upstream cribwork to protect loose fill within.

At the east end of the dam are remnants of a foundation and wheelpit for a large flour mill that once stood on the site. Brick walls for the wheel pit, part of a brick floor with an iron support for a penstock, and scattered remnants of trash rack mark the site. The flour mill was demolished following heavy damage from the Flood of 1927.

At the west end of the dam, new construction is underway to create a hydro-electric facility. A temporary dam has been erected to protect the work, which will include a headrace, turbine-generator structure, and a new dam that will extend across the river, using the present dam as part of the form for its upstream face.

HISTORICAL BACKGROUND

Burlington Woolen Mill Company had its origins in 1835 when a group of Burlington businessmen formed a company to manufacture merino-wool cloth, choosing a site for their mill on the north side of the Winooski River, which is the boundary between Burlington and the Town of Colchester, Vermont. This location, known as Winooski Falls, was already the site of small-scale manufacturing. In the late 18th century, Ira Allen built a sawmill at the upper falls, and by 1812 Moses Catlin was running a gristmill and oil mill at the lower falls on the south (Burlington) side.[2] Burlington Woolen Mill Company's first mill (no longer standing) was a 5 1/2 story brick building with a clerestory roof and domed belfry. Waterpower was provided by a V-shaped dam located about 100' north of the present dam, with a long canal leading to the mill, which stood west of the present mill.

In 1862, Burlington Woolen Mill Company received a fresh infusion of funds from a group of Boston capitalists that included Joseph Sawyer, a commission merchant and principal in the dry-goods firm of E. R. Mudge, Sawyer, & Company. Several large additions to the mill were made about this time. Undoubtedly to assure the coordinated use of the water privilege, the same interests acquired the gristmill on the Burlington side, which had been substantially enlarged in 1868. It was subsequently operated under the name Burlington Flouring Company; the local manager of both companies was F. C. Kennedy, Secretary of Burlington Woolen Mill Company.

Burlington Woolen Mill Company constructed the present dam in 1876. It is not known if the former dam, which was located about 100' upstream, had become deteriorated or if it was in some other way inadequate. It appears that the new dam offered a slight increase in head, and it certainly provided a larger forebay area. The dam at the time was regarded as a major improvement to the complex.[3]

The dam can be viewed as part of a series of expansions by Burlington Woolen Mill Company. In 1880 the company erected a large new mill closer to the river. Called the Colchester Merino Mill, it manufactured cotton yarn for use in hosiery. In 1895 the Winooski Woolen Mill was added to the west, replacing older structures that had stood on the site, and the Colchester Mill was extended to the south in 1902, doubling its size.

That same year the mills at Winooski Falls were taken over by the American Woolen Company, a large corporation headquartered in North Andover, Massachusetts, that acquired dozens of New England factories in an attempt to dominate American woolen production. In 1912 American Woolen Company added to the existing complex (which included the Chase Cotton Mill, built in 1892) with the construction of the Champlain Mill at the upper falls.

Winooski owes its identity to the industrial development that took place at the Falls. With the establishment of the woolen mill it became a small village characterized by a clustering of mills, stores, and workers' houses, and it soon became the commercial and political center for Colchester. With each expansion of the mills, Winooski became larger and more important, and in 1922 it was incorporated as a separate city.

The present project will not be the first use of the site to produce electricity: in the 1880s a dynamo in the flour mill powered the textile mill's electric lights, and from about 1894 to 1912, the dam provided power for the Burlington streetcar system, which also housed its generators in the flour mill.

ENGINEERING SIGNIFICANCE OF THE DAM

In its basic construction, Burlington Woolen Mill Company's 1876 dam is typical of 19th-century mill dams. It employs the timber-crib principal, in which large timbers are laid at right angles and spiked together, with the whole structure ballasted by a fill of stone and gravel; typically, both upstream and downstream faces of such dams were covered by wooden planking. Timber-crib textile mill dams represent a scaling-up of a vernacular technology used for countless 18th and 19th-century grist and saw mills. Many were quite large: the 1849 Holyoke (Massachusetts) dam, which was identical to this one in overall geometry and the size, shape and spacing of timbers, was over 1000' long. Timber-crib dams made use of readily available materials and the construction techniques, including mortised and pegged joints, were familiar to ordinary workmen of the period. Probably the biggest challenge in building such a dam was hauling the stone to the site and filling the cribwork; tramways for dump-carts were often constructed along the crest to facilitate filling.

One aspect of timber-crib dams that evolved (largely from unfortunate experiences) was the shape of the cross-section. Straight-faced dams such as the Winooski or Holyoke structures became less common as engineers attempted to smooth the flow of water running over the top. By 1870, most dams were built with a slanted downstream face to minimize erosion at the base. Indeed, erosion at the Holyoke dam had become so serious that another section of cribwork was added to the face, thereby providing a slanted spillway. Many timber-crib dams also had wooden aprons extending downstream to prevent underscour, though at Winooski there is no visible evidence of either such an apron or of serious erosion. Timber-crib dams, as well as masonry dams, were made obsolete in the early 20th century by reinforced-concrete construction.

What makes the Winooski dam notable in the history of engineering is that it is one of the earliest recorded uses of concrete as a structural material for dams. Its concrete fill, from all indications original to its 1876 construction, demonstrates the tentative first steps in a process by which the strength, low cost, and easy workability of concrete came to be recognized. As Condit has observed, concrete was initially viewed as a supplement to stone masonry; only gradually was it appreciated as a material that could be used by itself.

Prior to the 1870s, concrete in dam construction appears to have been limited to its use as a kind of water-resistant seal, such as the layer of "Beton" that had been applied to the upstream base of the dam at Holyoke. After the Civil War, increased production of "natural cements," as well as imports of Portland cement, accompanied a rising interest in concrete construction, and in 1871 the first American plant to make Portland cement was started in Copley, Pennsylvania. The Lynde Brook reservoir dam near Worcester, Massachusetts, completed in 1871, was one of the earliest dams to make structural use of the material: it had a concrete core wall embedded in an earthen dike. A similar core wall was employed in a New York City reservoir structure, the Boyd's Corner Dam, completed in 1872.

The Winooski dam is a timber analog to these early uses of concrete as a supplementary structure in earthen and masonry dams. In all these pioneering dams, it appears that the concrete was intended as both a barrier to water seepage and as a means of adding stability, in the case of Winooski, by making the fill into a rigid monolith. Such a use of concrete, relatively costly because both "natural" and Portland cements were expensive, were probably exceptional, as stone-filled timber-crib dams continued to be built in large numbers until about 1900. However, at least one other dam of the Winooski type has been recorded: the 1881 Des Moines River dam at Bentonsport, Iowa. It too was a timber-crib dam with concrete between the downstream face wall and back planking; however, the concrete part was only 1' thick, with the rest of the structure filled conventionally with stone and gravel.[4]

The concrete used in the Winooski dam probably made use of natural cement.[5] The cementitious material differs from standard Portland cement in a number of ways. First, chemical testing[6] on a sample revealed that a large amount (20% of the whole) was soluable in mild acid, suggesting that the cement was supplemented by a substantial amount of lime. "Stretching" cement with lime was a common practice in the 1870s since lime was much less expensive than cement.[7] However, free lime is considered highly undesireable in concrete, because its expansion during hydration (the process of water incorporation that makes lime and cement harden) weakens the result. Secondly, the cement contains a large amount of magnesia, undoubtedly because the limestone from which it was made was dolomite; Portland cement is usually held to no more than 4% magnesia. (The free lime also appears to be dolomitic in origin.) Finally, the cement matrix is far more heterogenous than is typical with Portland cement, which is manufactured at higher temperatures from controlled quantities of ingredients. Widely fluctuating proportions of silica (5-37%) and alumina (3-14%) suggest that their bonding with the calcium/magnesium oxides was irregular and incomplete.[8]

Despite its shortcomings by modern standards, the Winooski dam's concrete must be considered a success, especially given the period's limited understanding of concrete chemistry or even of the process of hydration. The concrete provided the dam with a fill material that was unsurpassed in strength, rigidity, and impermeability. The dam's very survival, when so many other timber-crib structures have succumbed, is itself a validation of the technique. The use of concrete undoubtedly was one of the chief reasons that the Burlington Free Press, describing the dam's completion in September 1876, proclaimed it "the best dam ever built in Vermont."[9]

NOTES

1. Wood identification by Lucinda McWeeney, Westport, CT.

2. The author of this documentation gratefully acknowledges the research of Vincent E. Feeney, who made available preliminary scripts for exhibit panels on the early history of the site.

3. Historical photographs of the area are numerous; however, since the point was to show a picturesque waterfall, they almost invariably were taken at high water and show no details of the dam. The only historical view showing the dam dry is in Round About Burlington, Vermont (Winooski: Vermont Illustrating Co., 1900).

4. W. P. Trowbridge, Reports on the Water-Power of the United States. Tenth Census of the United States, 1880 (Washington: Government Printing Office, 1887), Part 2, p. 385.

5. Such cement was made from limestone deposits that naturally contained clay as a source of silica. Ground up and heated, the calcium in the limestone formed silicates (and to a lesser extent aluminates) that gave the cement the desired property of hardening under water. Portland cement is a manufactured product in which chalk or limestone is combined with clay or shale, fired in a kiln to 1300-1400 degrees C., and then ground to a fine powder.

6. Analysis by William Parsons, Conn-Test, Inc., Wethersfield, CT. This is the common test for determining the amount of lime in historic mortar.

7. Bernard R. Green, "Cements and Concrete," Engineering News, 4 (March 3, 1877): 58.

8. Chemical composition determined through an electron microprobe analysis of ten areas of the matrix in the concrete sample (beam of 15 KeV, 800 picoamps).

9. Burlington Free Press, September 25, 1876.

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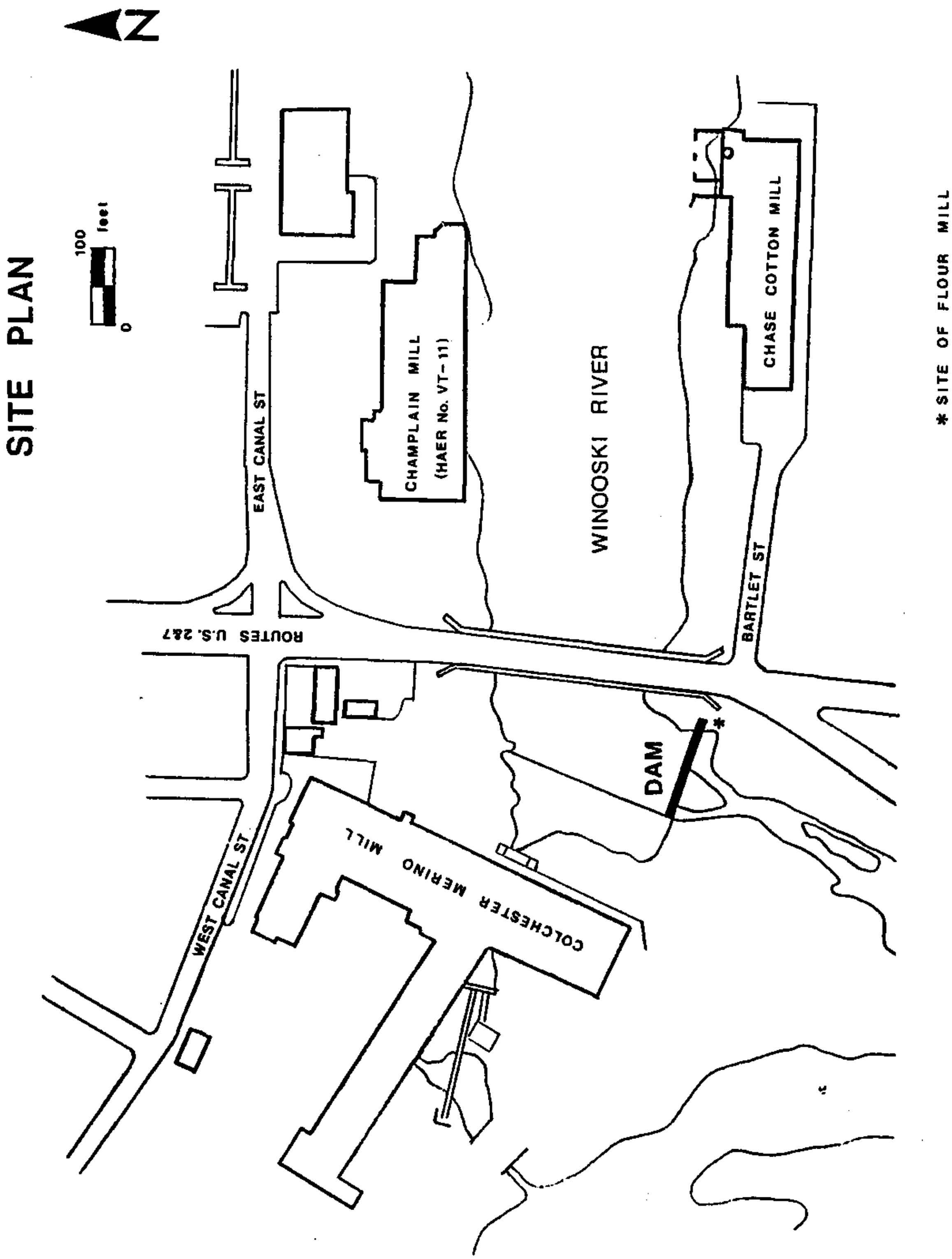
SITE PLAN
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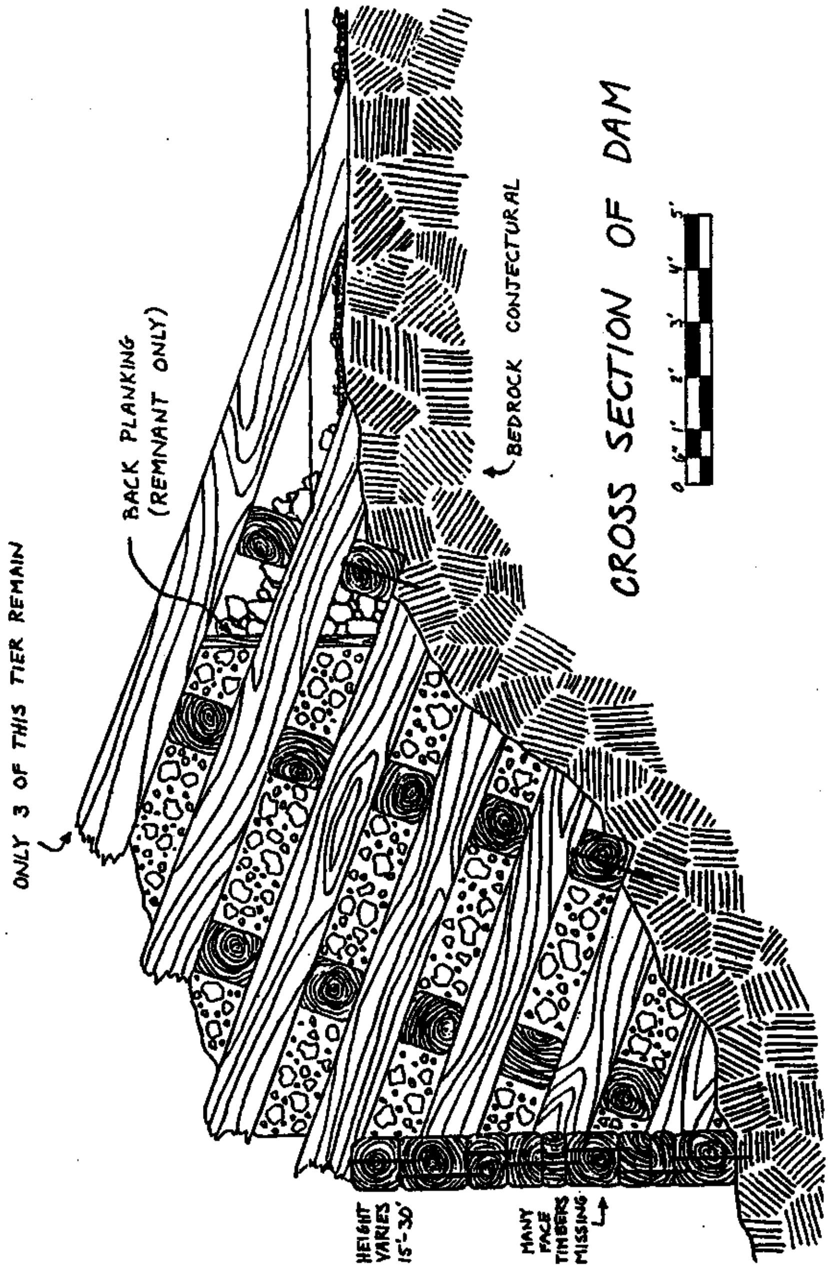
feet
N
EAST CANAL ST
CHAMPLAIN MILL
(HAER No. VT-11)
WINOOSKI RIVER
CHASE COTTON MILL
BARTLET ST
ROUTES U.S. 2&7
DAM
COLCHESTER MERINO MILL
WEST CANAL ST
* SITE OF FLOUR MILL


CROSS SECTION OF DAM
BACK PLANKING (REMNANT ONLY)
ONLY 3 OF THIS TIER REMAIN
BEDROCK CONJECTURAL
HEIGHT VARIES 15'-30'
MANY FACE TIMBERS MISSING
0 6" 1' 2' 3' 4' 5'